

**TRANSPORTATION SCIENCES
CRASH RESEARCH SECTION**

**Veridian/Calspan Operations
Buffalo, New York 14225**

CALSPAN REMOTE PASSENGER AIR BAG/INJURY INVESTIGATION

CALSPAN CASE NO. CA98-068

VEHICLE - 1994 PLYMOUTH VOYAGER

LOCATION - DELAWARE

CRASH DATE - JULY, 1996

Contract No. DTNH22-94-07058

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The crash investigation process is an inexact science which requires that physical evidence such as skid marks, vehicular damage measurements, and occupant contact points be coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants.

Because each crash is a unique sequence of events, generalized conclusions cannot be made concerning the crashworthiness of the involved vehicle(s) or their safety systems.

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<p>16. <i>Supplementary Notes</i></p>			
<p>17. <i>Abstract</i></p> <p>This remote investigation focused on the front-to-rear crash of a 1994 Plymouth Voyager and a 1991 Honda Accord. The Plymouth Voyager was equipped with a Supplemental Restraint System (SRS) that consisted of driver and right front passenger air bags. The air bags deployed as a result of the crash. The restrained 15 year old right front passenger of the Voyager sustained a left brachial plexus injury (AIS 2), fracture of the right 2nd metacarpal, hyphema of the right eye and minor facial abrasions, in the crash. The restrained driver and an unrestrained 11 year old boy, located on the floor in the front center of in the vehicle, were not injured.</p> <p>The driver of the Voyager became distracted when the 11 year old boy got out of his seat and moved forward between the vehicle's front seats. The boy was kneeling down and was attempting to put a compact disc in a remote CD player that was situated on the center floor area of the vehicle. The right front passenger turned to her left and attempted to assist the boy. The distracted driver had taken her eyes off the road and failed to recognize a sudden back up in traffic. The Plymouth rear-ended a 1991 Honda Accord that had stopped directly in front of them. The Plymouth Voyager experienced a longitudinal delta V of approximately 24 km/h (15 mph). The magnitude of the vehicle's deceleration was above the threshold to warrant deployment of the Voyager's Supplemental Restraint System. The deploying right front passenger air bag contacted the out-of-position, 15 year old female right front occupant. She was transported to the emergency room of a local hospital and then transferred to a regional level one trauma center. The passenger was hospitalized nine days.</p>			
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CALSPAN REMOTE PASSENGER AIR BAG/INJURY INVESTIGATION

CALSPAN CASE NO: CA98-068

VEHICLE: 1994 PLYMOUTH VOYAGER

LOCATION: DELAWARE

CRASH DATE: JULY 1996

BACKGROUND

This remote investigation focused on the front-to-rear crash of a 1994 Plymouth Voyager and a 1991 Honda Accord. The Plymouth Voyager was equipped with a Supplemental Restraint System (SRS) that consisted of driver and right front passenger air bags. The air bags deployed as a result of the crash. The restrained 15 year old right front passenger of the Voyager sustained a left brachial plexus injury (AIS 2), fracture of the right 2nd metacarpal, hyphema of the right eye and minor facial abrasions, in the crash. The restrained driver and an unrestrained 11 year old boy, located on the floor in the front center of in the vehicle, were not injured.

The Field Operations Branch of the National Highway Traffic Safety Administration (NHTSA) was informed of the crash, in November 1998, by an attorney representing the injured party. NHTSA in-turn assigned an investigation of the crash to the Special Crash Investigation (SCI) team at Veridian/ Calspan on December 11, 1998. Due to the lapse of time between the date of the crash and notification, a remote investigation was conducted.

SUMMARY

Crash Site

This three-vehicle crash occurred during the daylight hours of July 1996. The crash occurred in a straight and level section of a north/south, four lane, divided highway, located in a resort area of the state. At the time of the crash, the weather clear and was not a contributing factor. The police report indicated that traffic was extremely heavy at the time of the crash and was moving slower than the posted 89 kph (55 mph) speed limit.

Pre-Crash

The 1994 Plymouth Voyager was, in the inboard (left) lane of the roadway, traveling south in a line of traffic heading for the beach. The traffic was congested as referenced by the police report. The speed of the Voyager was approximately 32 km/h (20 mph), as reported by the vehicle's driver. The vehicle was operated by a restrained 33 year old female. The right front passenger of the Voyager was a 15 year old female with a reported height/weight of 160 cm (63 in) and 50 kg (110 lb) respectively. She was also restrained at the time of the crash by the vehicle's 3-point lap and shoulder belt system. The driver's 11 year old son was seated in the center position of the Voyager's 2nd seat.

Crash

The driver of the Voyager became distracted when the 11 year old boy got out of his seat and moved forward between the vehicle's front seats. The boy was kneeling down and was attempting to put a compact disc in a remote CD player that was situated on the center floor area of the vehicle. The right front passenger turned to her left and attempted to assist the boy. The distracted driver had taken her eyes off the road and failed to recognize a sudden back up in traffic. A 1991 Honda Accord had stopped directly in front of Plymouth Voyager. The driver redirected her vision to the front, realized the impending crash and rapidly applied the brakes. The crash occurred with the front of the Voyager impacting the rear of the Accord in 12/6 o'clock impact configuration. The force of the crash displaced the Accord forward into a minor front-to-rear secondary impact with a 1981 Audi 400. The occupant's of the Honda and Audi were uninjured and those vehicle's drove away from the crash under their own power.

The Plymouth Voyager experienced a longitudinal delta V of approximately 24 km/h (15 mph). The magnitude of the vehicle's deceleration was above the threshold to warrant deployment of the Voyager's Supplemental Restraint System. The deploying right front passenger air bag contacted the out-of-position, 15 year old female right front occupant. She was transported to the emergency room of a local hospital and then transferred to a regional level one trauma center. The passenger was hospitalized nine days. The medical record indicated the passenger sustained multiple facial abrasions, a left hyphema, a fracture of the right 2nd metacarpal and a left (incomplete) brachial plexus injury. The EMS report stated she was also unconscious for an unknown length of time post-crash and amnesic to the event. The restrained driver and unrestrained male passenger were not injured in the crash.

AIR BAG VEHICLE

The 1994 Plymouth Voyager was identified by a Vehicle Identification Number (VIN): 1P4GH44R0RX (production sequence deleted). The vehicle was configured as a passenger minivan with an extended wheelbase and had gross vehicle weight rating of approximately 2722 kg (6000 lb). The vehicle was equipped with a 3.3 liter V6 engine linked to a 4-speed automatic transmission. The vehicle was also equipped with a 4-wheel anti-lock braking system. The vehicle reportedly was driveable post-crash. It was subsequently repaired and then resold a short time after the crash.

Figures 1 through 3 are views of the frontal damage sustained by the Plymouth Voyager. The photographs were taken a short time after the crash by persons representing the legal interests of the vehicle's occupants. The photographs indicated the Voyager sustained approximately 13 to 18 cm (5 to 7 inches) of longitudinal deformation across the full 157 cm (62 in) front end width

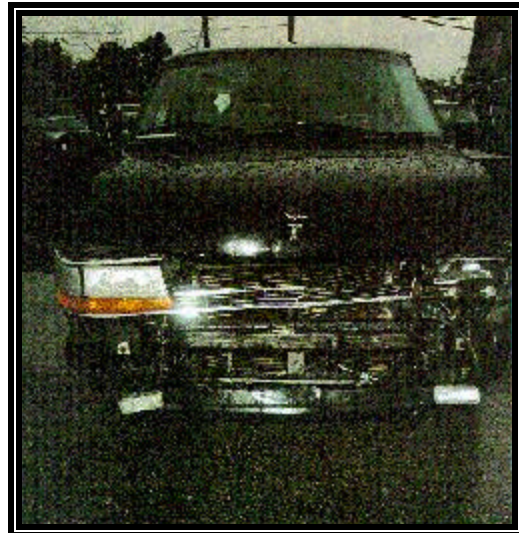


Figure 1: Front view of the 1994 Plymouth Voyager.

of the vehicle. The damage was confined to the frontal structure of the vehicle forward of the radiator support plane. The damaged components included: the bumper cover, bumper reinforcement, grille, hood left headlamp structure and left front fender. The Barrier Model of the WINSMASH model calculated a damage-based delta V of approximately 24 km/h (15 mph). The Collision Deformation Classification of the vehicle was 12-FDEW-01.

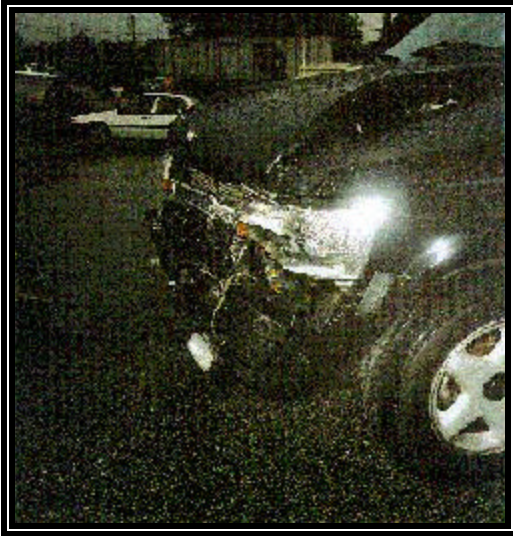


Figure 2: Left lateral view across the frontal -plane.



Figure 3: Right side view of the frontal damage.

INTERIOR DAMAGE

Damage to the Plymouth Voyager's interior was resultant to contact from the vehicle's occupants and deployment of the vehicle's Supplemental Restraint System. There was no interior damage associated to the external forces of the crash. The interior damage identified below was determined through the examination of the available photographs.

Two scuff marks were identified on the driver's knee bolster and were attributed to contact with the driver's lower extremities. These contacts reportedly did not produce any injury. The glass of the center rear view mirror was fractured, **Figure 4**. Additionally, the upper left center aspect of the windshield was fractured immediately forward of the center mirror. These fractures probably occurred as a result contact from the expanding right front passenger air bag.

The photograph also reveals the right sunvisor was down at the time of the crash. The deformation of the sunvisor and mirror fracture were also caused by contact from the expanding right front passenger air bag. The fractured mirror was displaced from its mounting.

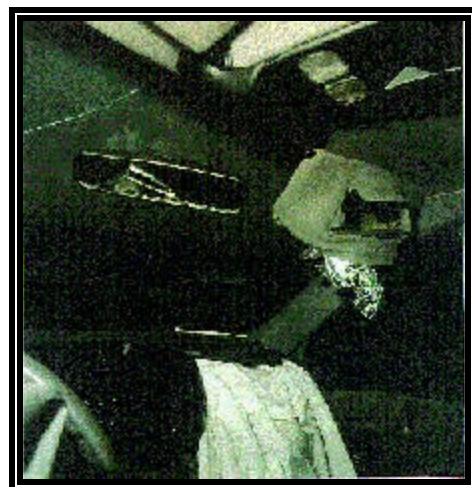


Figure 4: Left view of the front center interior.

MANUAL RESTRAINT SYSTEM

The front seat positions in the 1994 Plymouth Voyager were each equipped with a manual 3-point restraint system. The front seat belt systems consisted of a continuous loop lap and shoulder belt webbing with a sliding latch plate. An inertia activated locking retractor was located in the base of each B-pillar. The restraint's upper anchorages (D-rings) were adjustable. The police report indicated both front occupants were restrained by the manual belt system. SCI analysis of the occupant's kinematic and injury patterns indicated the occupants were restrained as well.

SUPPLEMENTAL RESTRAINT SYSTEM

The Supplemental Restraint System in the 1994 Plymouth Voyager consisted of a driver and right front passenger air bags. The vehicle's SRS detected an above threshold crash severity and had deployed the air bags subsequent to the impact. The driver air bag was designed in the typical manner and was located in the center hub of the steering wheel. The right front passenger air bag was a top mount design located in the right aspect of the instrument panel. **Figure 5** is a view of the right front passenger air bag module. The mid aspect of the instrument panel, aft of the module, was partially ruptured during the deployment sequence. This partial rupture was indicative of an altered deployment sequence. The forward position of the right front occupant probably impeded the normal deployment of the air bag sufficiently to cause a pressure to build within the module. The panel then partially ruptured due to the continued expansion of the air bag within the module.

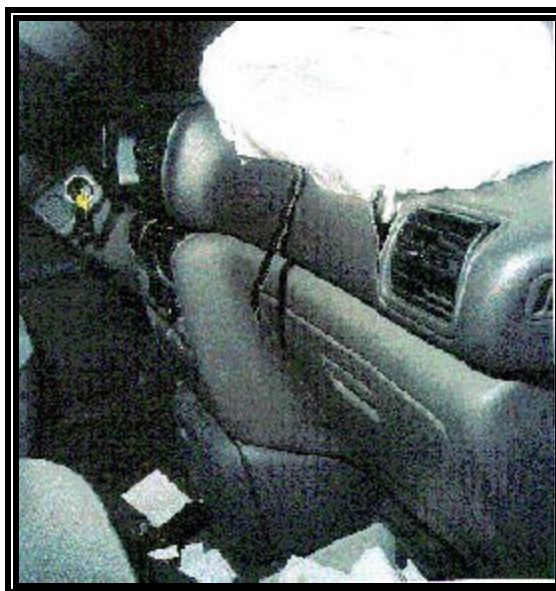


Figure 5: Right view of the passenger air bag module.

RIGHT FRONT PASSENGER DEMOGRAPHICS

Age/Sex:	15 year old/female
Height:	160 cm (63 in)
Weight:	50 kg (110 lb)
Restraint Usage:	3-point manual lap and shoulder belt
Usage Source:	SCI analysis of kinematic and injury patterns/Police Accident Report
Eye wear:	Soft contact lenses

RIGHT FRONT PASSENGER INJURIES

Injury	Injury Severity (AIS 90)	Injury Mechanism
Unconscious - length of time unknown, GSC=9 initial observation at the scene by EMS, amnesic to crash event	Moderate (160606.2,0)	Deploying right front passenger air bag
Incomplete Brachial Plexus Injury, avulsion of C7, C8 and T1 nerve roots	Moderate (630216.2,6)	Inertial/rebound contact with right front seat back
Fracture of the right 2 nd metacarpal	Moderate (752002.2,1)	Unidentified rebound contact
Hyphema - right eye	Minor (240604.1,1)	Deploying right front passenger air bag
Forehead abrasion	Minor (290202.1,7)	Deploying right front passenger air bag
Abrasion of the right eyelid	Minor (297202.1,1)	Deploying right front passenger air bag
Multiple abrasions - nose	Minor (290202.1,4)	Deploying right front passenger air bag
Anterior chest abrasions	Minor (490202.1,9)	Deploying right front passenger air bag

Note: the above injuries were identified from the EMS report, Hospital record, Discharge Summary Specialist Referral records and Occupational Therapy reports

RIGHT FRONT PASSENGER KINEMATICS

Prior to the crash, the 11 year old male, seated in the 2nd seat, unlatched his seat belt and moved forward into the center front area of the vehicle. The boy was reportedly kneeling down and attempting in place a compact disc into the vehicle's remote CD player. The CD player was located on the floor of the vehicle.

The right front passenger in the vehicle was a 15 year old female. She was restrained by the vehicle's 3-point lap and shoulder belt and was initially seated with a normal posture. In response to the boy's actions, she probably turned her torso and head slightly to left and leaned forward and down to assist the young boy. She probably was reaching out with both of her arms. This action placed the right front

passenger out-of-position, toward the inboard side of the air bag. Her forward motion would have spooled out additional webbing from the shoulder restraint. Immediately prior to the crash, the driver rapidly applied the brakes. The rapid vehicular deceleration locked the 3-point restraint's inertial reel. As the passenger initiated a forward trajectory in response to the braking force, she also loaded the restraint. The passenger's right shoulder and upper torso loaded the shoulder belt webbing first. This action would cause the passenger to rotate to the right and become more centered on the air bag. Due to the sudden vehicle deceleration, the passenger lost her balance and also may have begun to straighten up and/or brace herself by reaching forward with her arms.

Upon impact, the vehicle's Supplemental Restraint System deployed. The 12 o'clock direction of the impact caused the right front passenger to initiate a forward trajectory and move into contact with the expanding air bag. The partially expanded air bag contacted the passenger's anterior chest, face, and head. The expansion of the air bag caused abrasions to the forehead, nose and anterior chest. During the expansion, the air bag fabric removed the contact lens from the passenger's right eye and caused the hyphema. The contact lens of the left eye was also damaged. The passenger was rendered unconscious due to the contact with the expanding air bag and was amnesic to the events of the crash. The passenger's forward position and interaction with the expanding air bag altered the normal deployment path of the air bag resulting in the pressurization of the module and the partial rupture of the instrument panel, **Figure 5**.

The altered path of the air bag caused the bag to contact the center mirror and right sunvisor. The air bag contacted the back side of the center mirror and rotated the mirror to the left about its pedestal mount. The upper left corner of the mirror contacted and fractured the left center aspect of the windshield. The mirror's surface was also fractured due to the contact. The air bag also deformed the right sunvisor and caused the fracture of the courtesy mirror, **Figure 4**.

The air bag's continued expansion caused the passenger to move rearward and into contact with the right front seat back. This contact arrested the rearward trajectory of the passenger's torso. The sudden deceleration of her body allowed her left arm and head/neck complex to flail rearward about the left shoulder and upper thoracic spine, respectively. The head was probably also rotating to left. This flail/torque motion caused the avulsion of the nerve roots C7, C8 and T1 resulting in the left incomplete brachial plexus injury.